Thrust Vector Control (TVC) Learning Center

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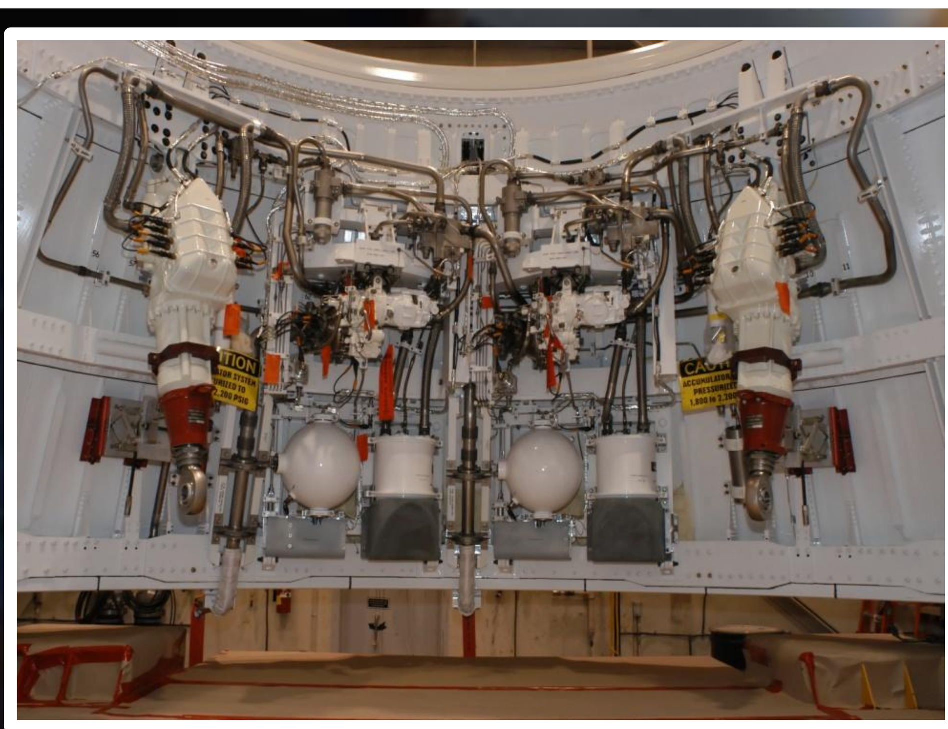
Background

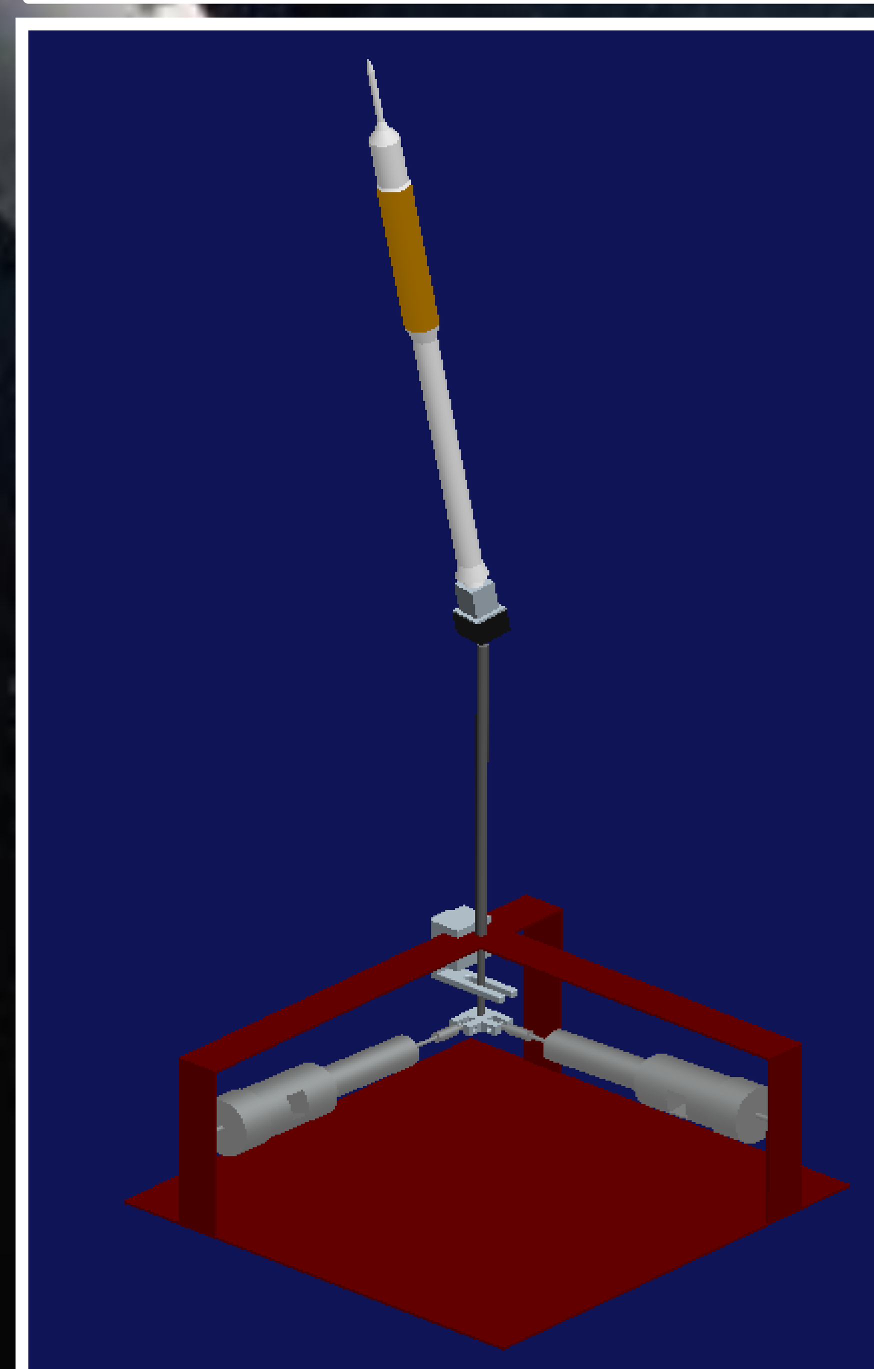
- Thrust vector control (TVC) is often employed to guide rockets in the desired flight trajectory.
- In most TVC system s two orthogonal actuators are used to gimbal the engine nozzle and in turn vector the thrust, keeping the rocket on the flight path.
- TVC is a complex system, requiring many mechanical components and controls. The purpose of our desktop learning center was to demonstrate the concept and function of TVC.



Methodology

- TVC system modeled as a spherical inverted pendulum
- Further developed a pre-existing mechanical set-up to represent the inverted pendulum model
- Spherical pendulum decoupled into two planar pendulum systems, which are individually controlled by linear voice-coil actuators
- State-space model developed using Lagrangian mechanics and then linearized
- Calibrated measurement devices to attain proper inputs for state-space model
- Linear Quadratic Regulator (LQR) Controller applied to control unstable system
- Closed-loop feedback achieved via LabVIEW

TVC Desktop Learning Center Model



Pro-E Model

Project Objectives

- Design a 2-axis inverted pendulum mechanical system to demonstrate TVC
- Implement a control system to accomplish dual-axis control of the mechanical system
- Create a Learning Center with working model, Pro-E simulation, and video in order to explain how TVC operates

Design

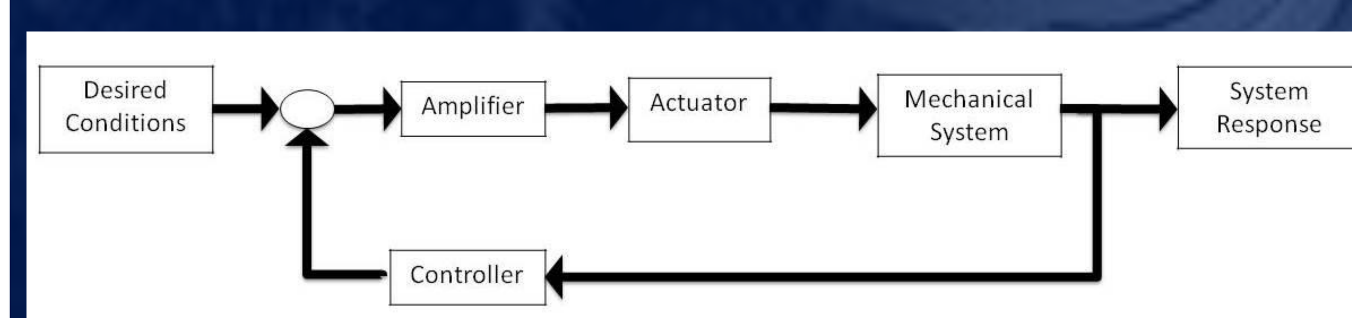
Hardware

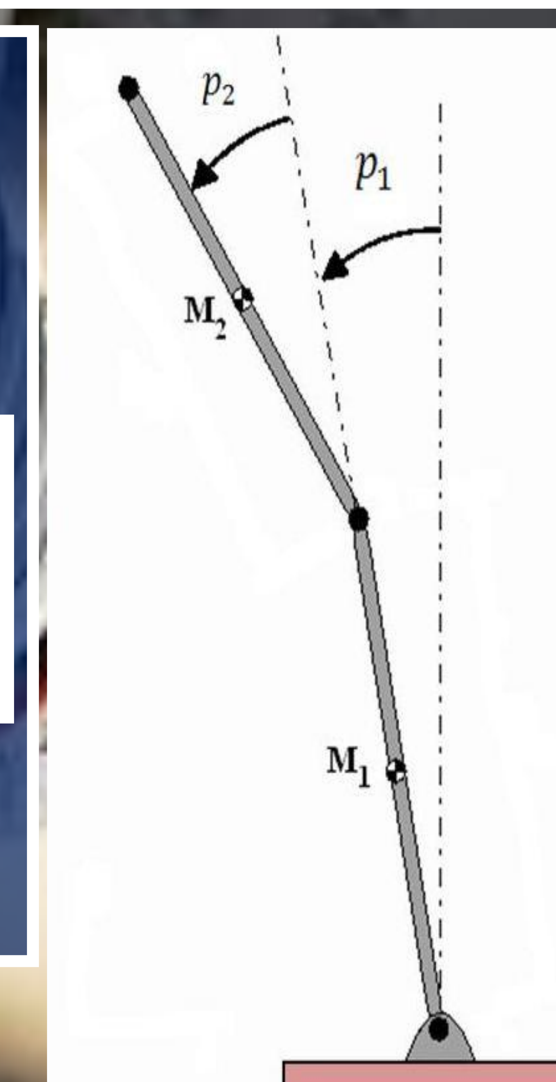
- 2 linear voice-coil actuators
- 2 amplifiers
- Measurements taken via 2 rate gyroscopes, 2 potentiometers, and 2 linear encoders
- Ares I Model Rocket

Control

- Apply LQR to determine gain which stabilizes system
- LQR converts transfer function from open-loop to closed-loop
- Inputs: angle and angular velocity of rod and rocket
- Outputs: force applied to arm by actuator

Control System Block Diagram





Acknowledgements: Dr. Sixx, Randy McGuire, Jeff Holmes, Lem Vaughn, John Wiley, Matt Canella, Tim Duquette, and the Propulsion Academy